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(12) **United States Patent**
Tinaphong et al.

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(45) **Date of Patent: Dec. 8, 2015**

(54) **WIRELESS AUDIO COUPLER AND AMPLIFIER FOR MOBILE PHONE, TABLET DEVICE, MP3 PLAYER AND THE LIKE**

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(73) Assignee: **VOXX International Corporation**, Hauppauge, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 192 days.

(21) Appl. No.: **14/109,218**

(22) Filed: **Dec. 17, 2013**

(65) **Prior Publication Data**

US 2014/0169605 A1 Jun. 19, 2014

Related U.S. Application Data

(63) Continuation-in-part of application No. 29/466,502, filed on Sep. 9, 2013.

(60) Provisional application No. 61/738,545, filed on Dec. 18, 2012, provisional application No. 61/836,472, filed on Jun. 18, 2013.

(51) **Int. Cl.**
H04R 1/02 (2006.01)
H04R 1/28 (2006.01)

(52) **U.S. Cl.**
CPC ***H04R 1/028*** (2013.01); *H04R 1/2834* (2013.01); *H04R 2420/07* (2013.01); *H04R 2430/01* (2013.01)

(58) **Field of Classification Search**
CPC H04R 2499/11; H04R 5/02
USPC 381/334
See application file for complete search history.

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2013/0267284	A1*	10/2013	Ryu	H04W 88/06 455/575.7

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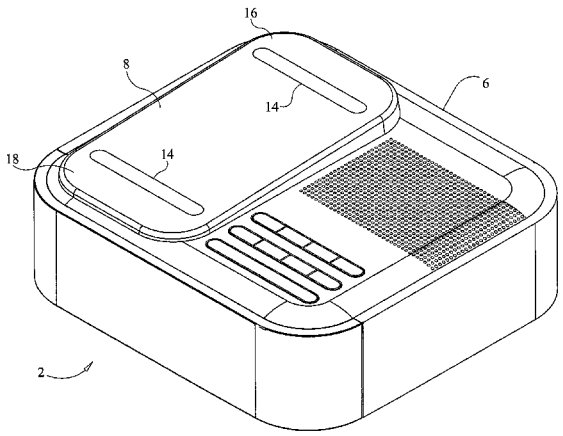
* cited by examiner

Primary Examiner — Simon King
(74) *Attorney, Agent, or Firm* — Gerald T. Bodner

(57) **ABSTRACT**

An electronic amplifier device amplifies magnetic audio signals emanating from a portable electronic device placed thereon. The electronic amplifier device includes a housing having a designated area for placement of the portable electronic device thereon, an amplifier circuit, and at least one loudspeaker electrically coupled to the amplifier circuit. A wireless audio coupler circuit situated within the electronic amplifier device includes a magnetic signal pick-up coil which is situated in close proximity to the designated area on the housing. The magnetic signal pick-up coil senses magnetic signals emanating from the portable electronic device placed on the designated area of the housing, and the electronic amplifier device amplifies these signals and provides them to the loudspeaker.

13 Claims, 13 Drawing Sheets



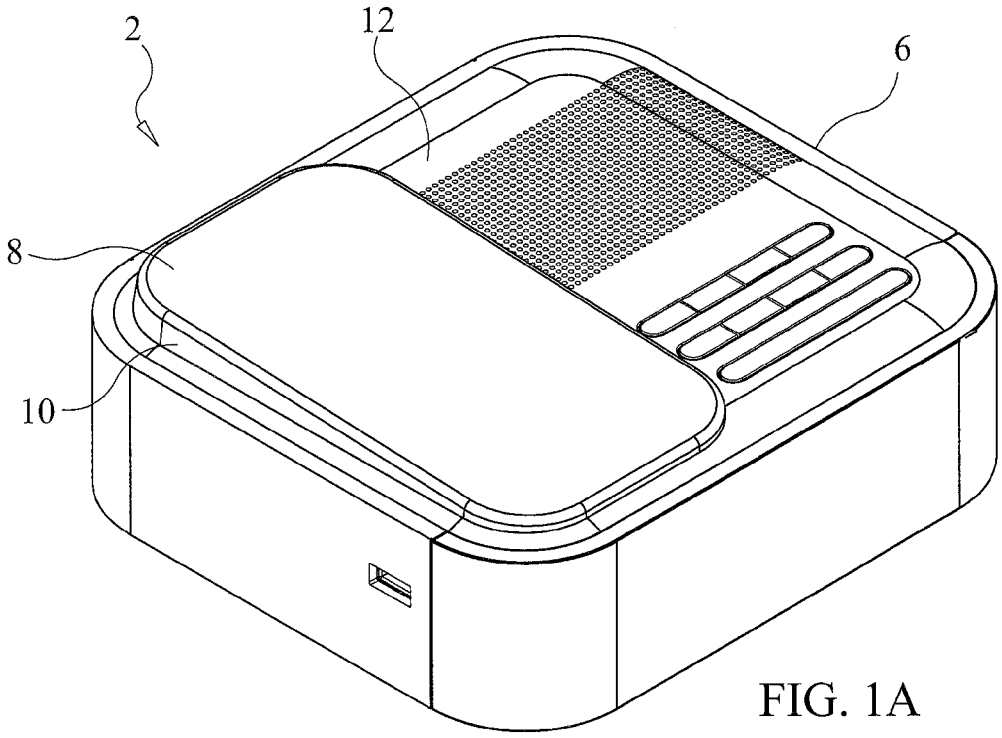


FIG. 1A

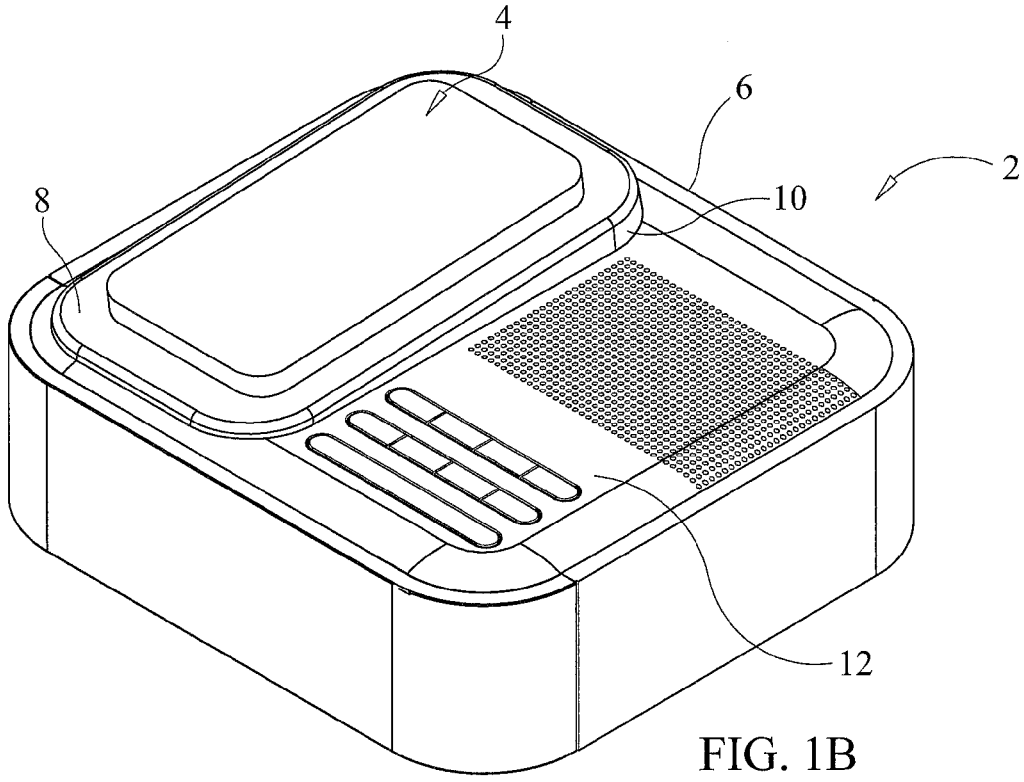


FIG. 1B

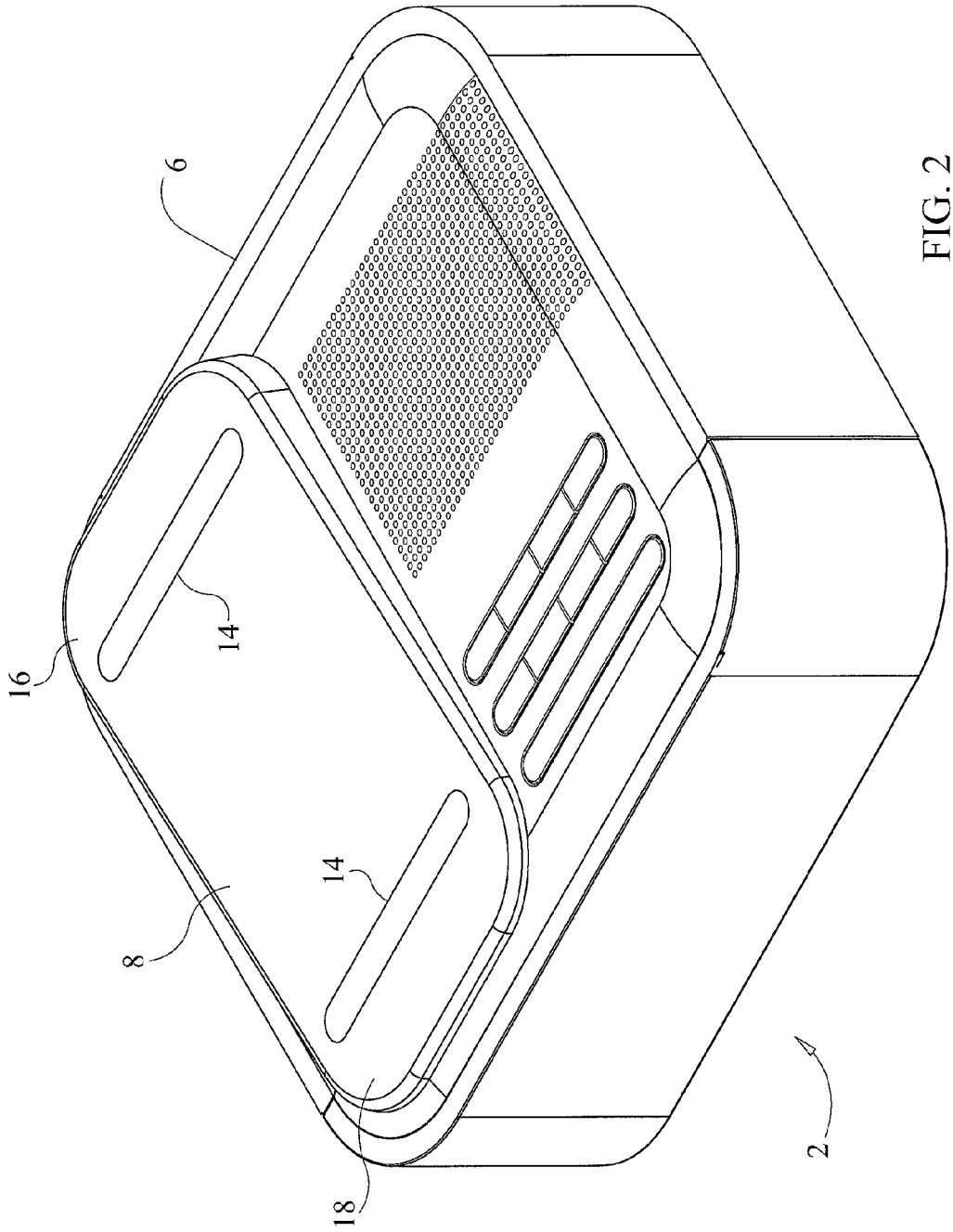
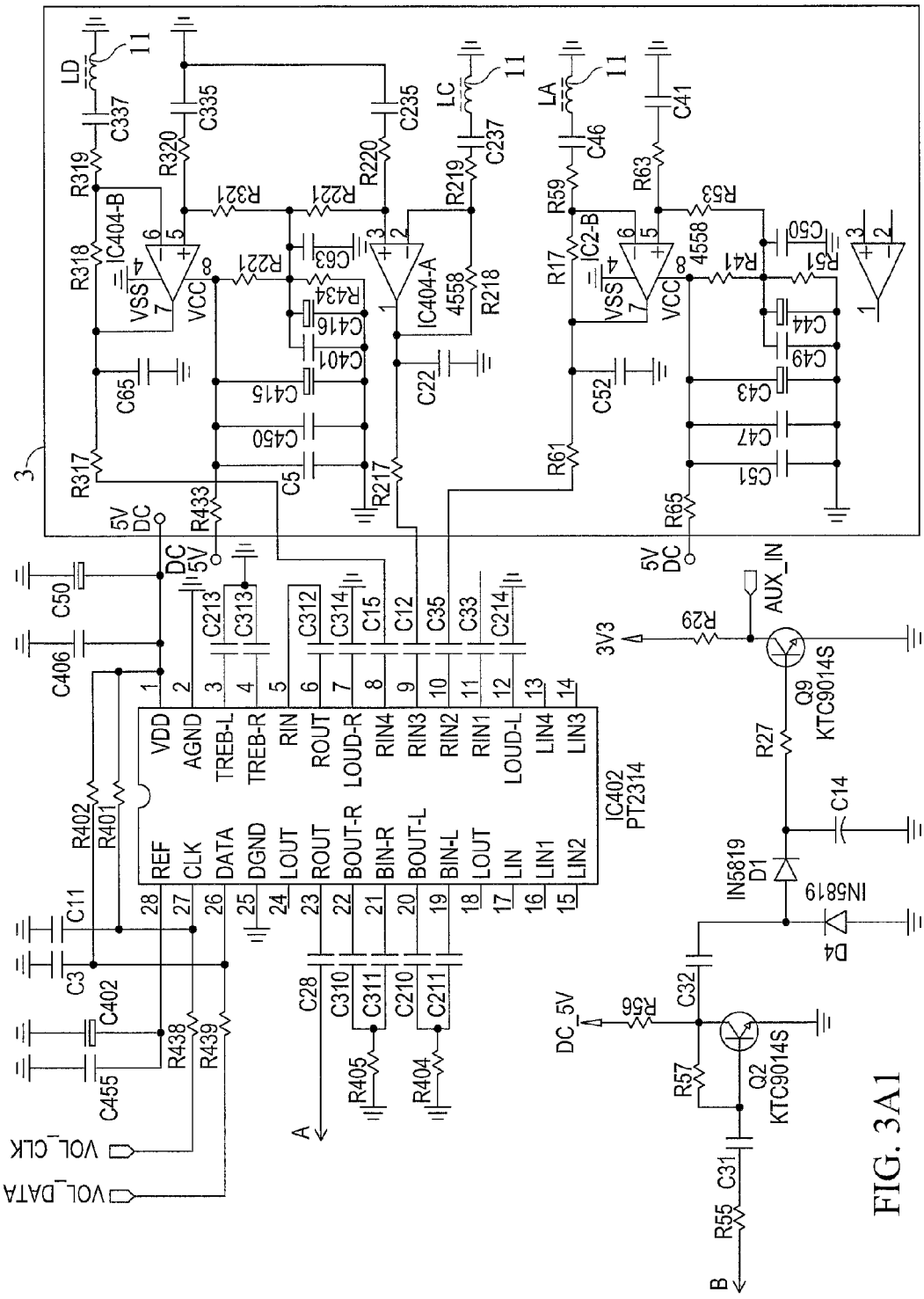


FIG. 2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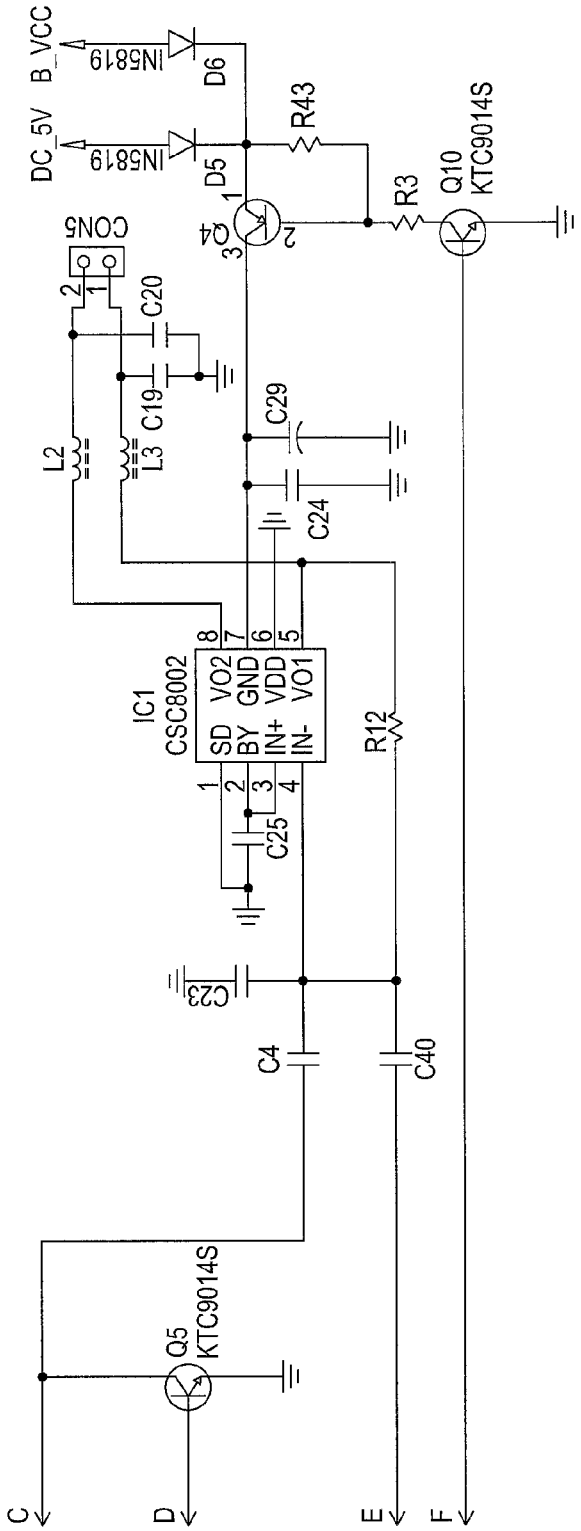
PT2314
VDD
AGND
TREB-L
TREB-R
RIN
ROUT
LOUD-R
RIN4
RIN3
RIN2
RIN1
LOUD-L
LIN4
LIN3
REF
CLK
DATA
DGND
LOUT
ROUT
BOUT-R
BIN-R
BOUT-L
BIN-L
LOUT
LIN
LIN1
LIN2
IC404-B
IC404-A
IC2-B
4558
VSS
VCC
LD
LC
LA
AUX_IN
Q9
KTC9014S
Q2
KTC9014S
IN5819
D1
D4
3V3
5V
DC
DC_5V
VOL_CLK
VOL_DATA
A
B

FIG. 3A1


B_VCC
DC_5V
IN5819
D6
D5
R43
Q4
R3
Q10
KTC9014S
CON5
C20
C19
L2
L3
C29
C24
IC1
CSC8002
SD
BY
IN+
IN-
VO2
GND
VDD
VO1
R12
C25
C23
C4
C40
Q5
KTC9014S
C
D
E
F

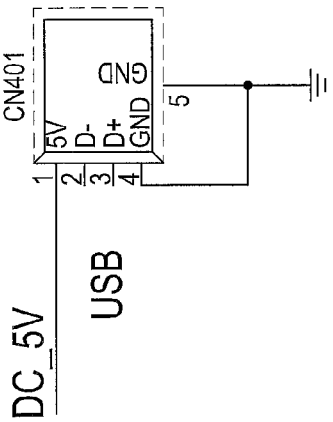

CN401
5V
D-
D+
GND
GND
DC_5V
USB

FIG. 3A2

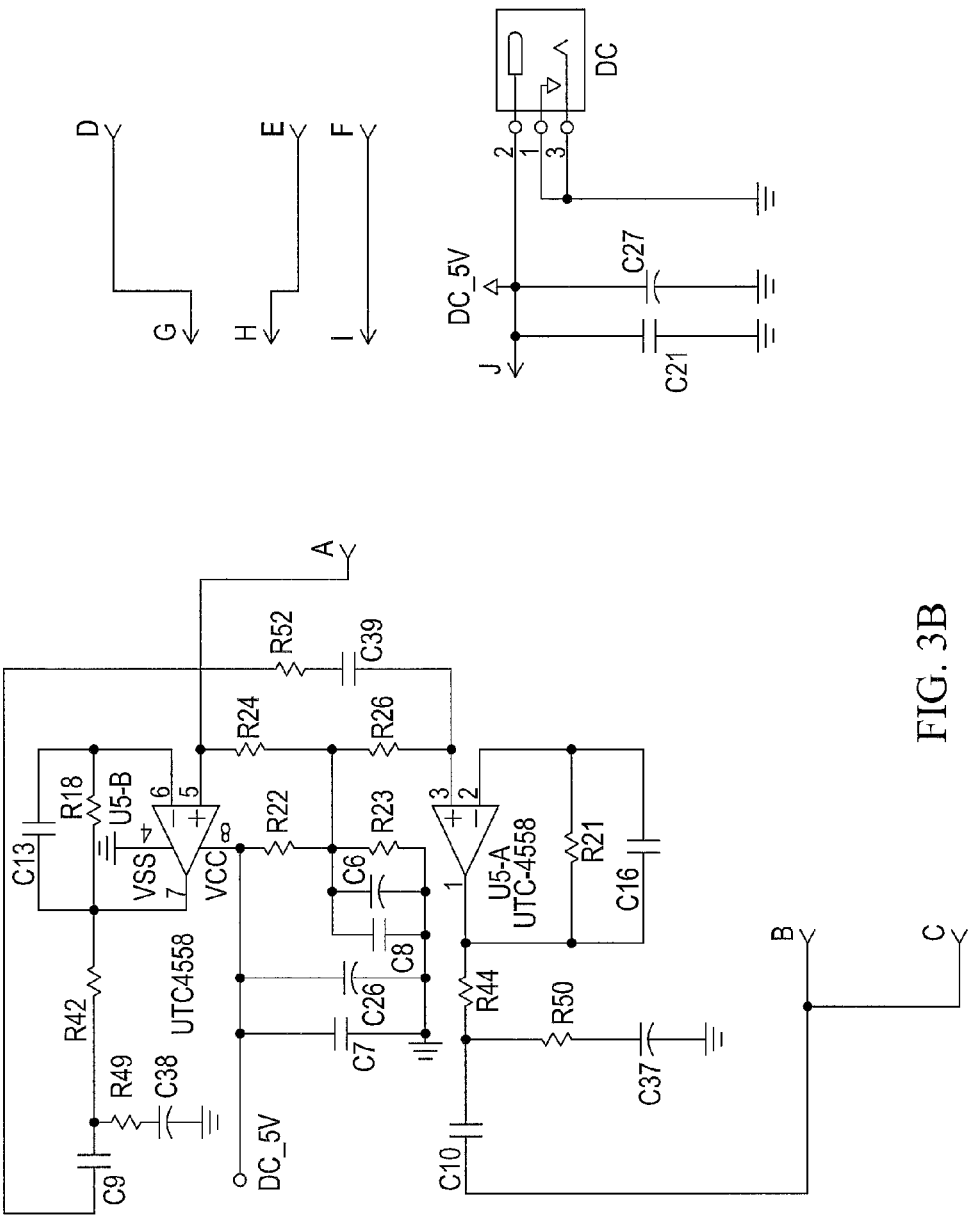

A
B
C
D
E
F
G
H
I
J
DC
DC_5V
C27
C21
R52
C39
R24
R26
R18
U5-B
R22
R23
C13
C6
C8
C26
C7
R42
R49
C38
C9
UTC4558
VSS
VCC
DC_5V
U5-A
UTC-4558
R21
C16
R44
R50
C37
C10

FIG. 3B

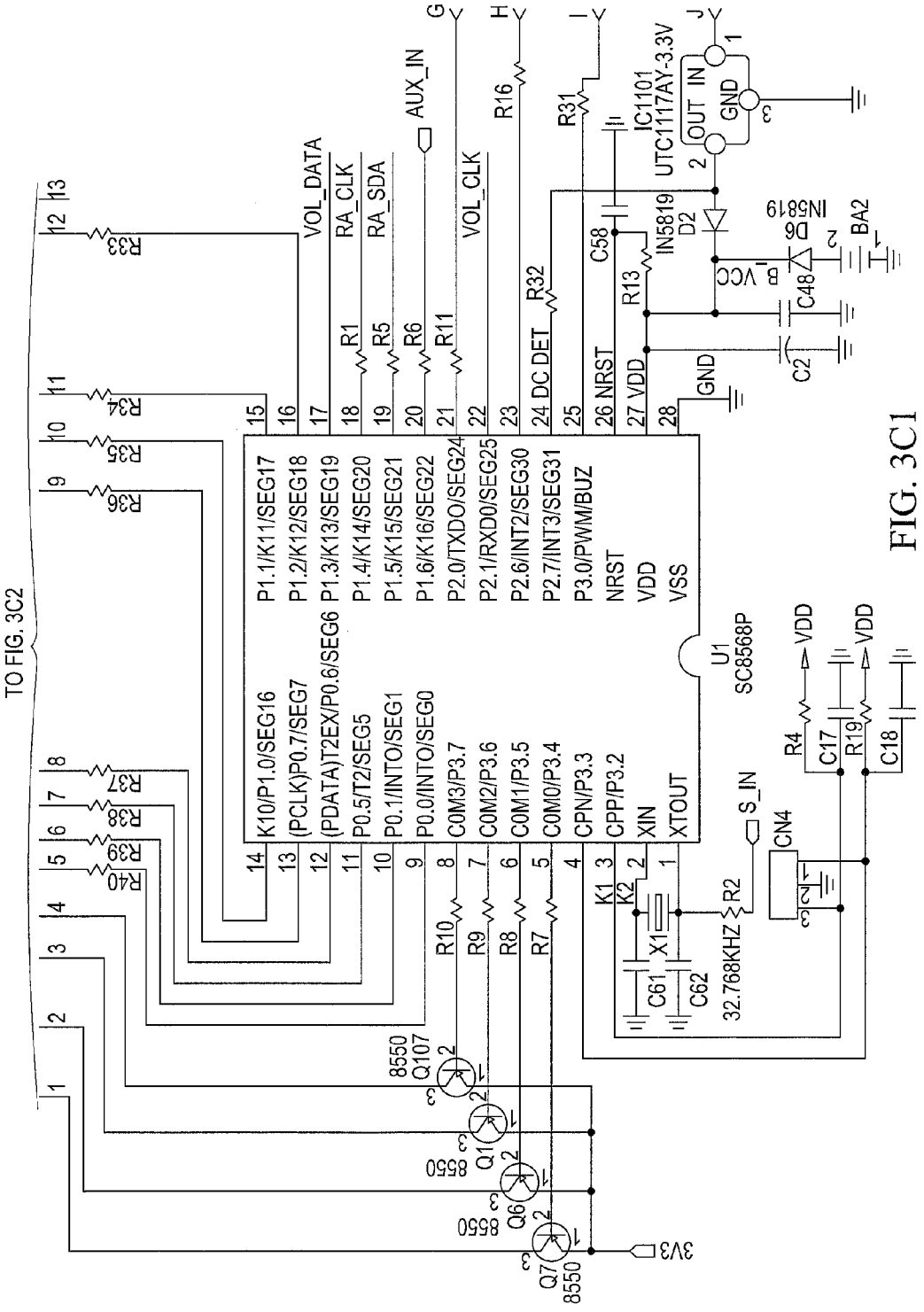
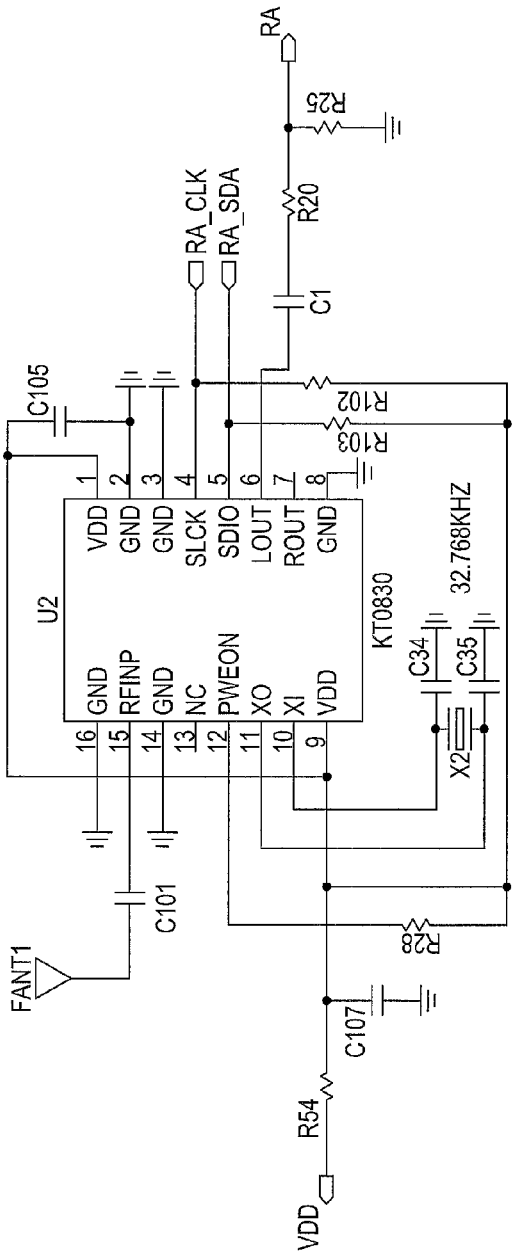

TO FIG. 3C2
P1.1/K11/SEG17
P1.2/K12/SEG18
P1.3/K13/SEG19
P1.4/K14/SEG20
P1.5/K15/SEG21
P1.6/K16/SEG22
P2.0/TXDO/SEG24
P2.1/RXD0/SEG25
P2.6/INT2/SEG30
P2.7/INT3/SEG31
P3.0/PWM/BUZ
NRST
VDD
VSS
K10/P1.0/SEG16
(PCLK)P0.7/SEG7
(PDATA)T2EX/P0.6/SEG6
P0.5/T2/SEG5
P0.1/INTO/SEG1
P0.0/INTO/SEG0
C0M3/P3.7
C0M2/P3.6
C0M1/P3.5
C0M0/P3.4
CPN/P3.3
CPP/P3.2
XIN
XTOUT
U1
SC8568P
VOL_DATA
RA_CLK
RA_SDA
AUX_IN
VOL_CLK
DC DET
NRST
VDD
GND
R33
R34
R35
R36
R37
R38
R39
R40
R1
R5
R6
R11
R16
R31
R32
R13
R10
R9
R8
R7
R2
C58
C2
C48
C61
C62
X1
32.768KHZ
K1
K2
S_IN
CN4
R4
R19
C17
C18
VDD
IC1101
UTC1117AY-3.3V
OUT
IN
GND
D2
IN5819
D6
IN5819
B_VCC
BA2
8550
Q107
Q1
Q6
Q7
3V3

FIG. 3C1


RA
R25
R20
C1
RA_CLK
RA_SDA
C105
R102
R103
U2
VDD
GND
GND
SLCK
SDIO
LOUT
ROUT
GND
KT0830
32.768KHZ
C34
C35
X2
GND
RFINP
GND
NC
PWEON
XO
XI
VDD
C101
FANT1
R28
C107
R54
VDD

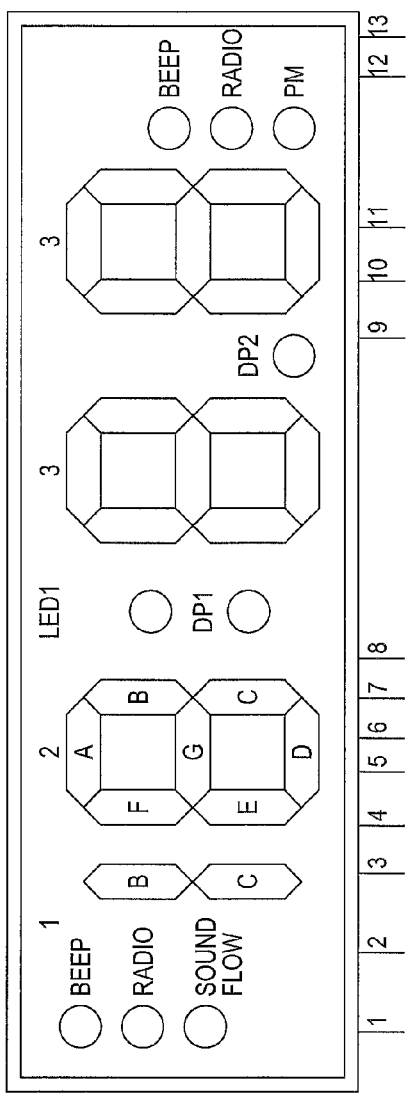

BEEP
RADIO
PM
DP2
LED1
DP1
BEEP
RADIO
SOUND FLOW
A
B
C
D
E
F
G
FROM FIG. 3C1

FIG. 3C2

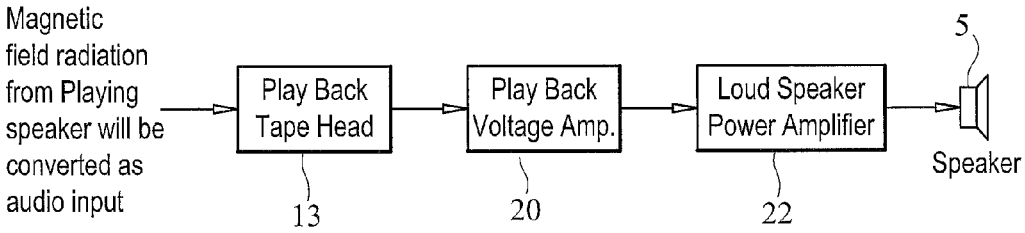

Magnetic field radiation from Playing speaker will be converted as audio input
Play Back Tape Head
Play Back Voltage Amp.
Loud Speaker Power Amplifier
Speaker
5
13
20
22

FIG. 4

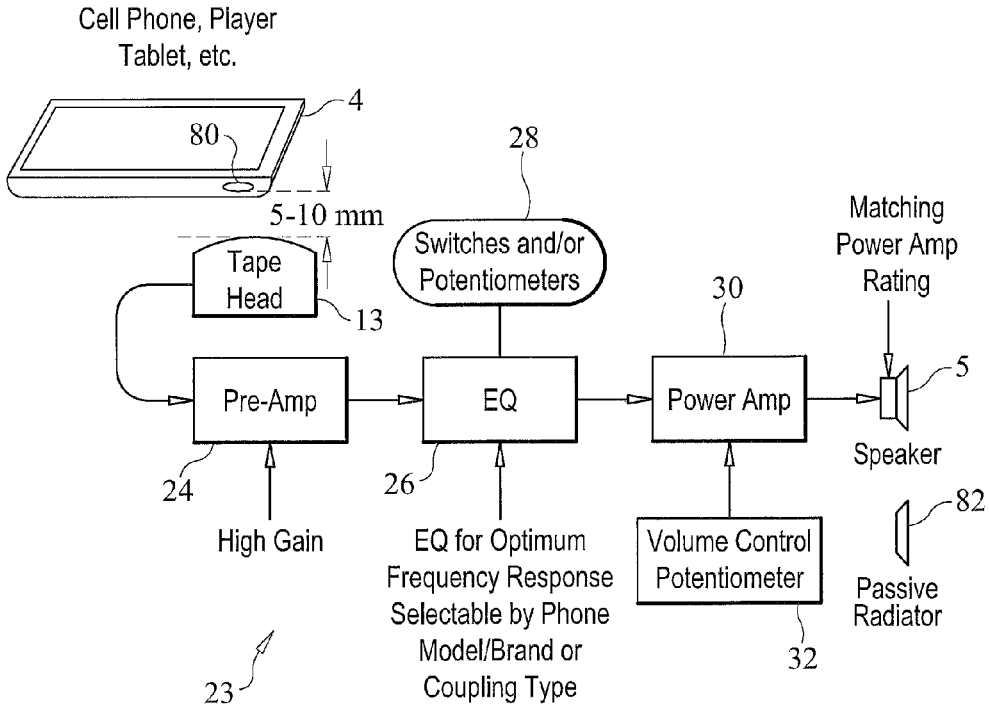

Cell Phone, Player Tablet, etc.
4
80
5-10 mm
28
Switches and/or Potentiometers
Matching Power Amp Rating
Tape Head
13
30
Pre-Amp
EQ
Power Amp
5
Speaker
24
26
82
High Gain
EQ for Optimum Frequency Response Selectable by Phone Model/Brand or Coupling Type
Volume Control Potentiometer
Passive Radiator
32
23

FIG. 5

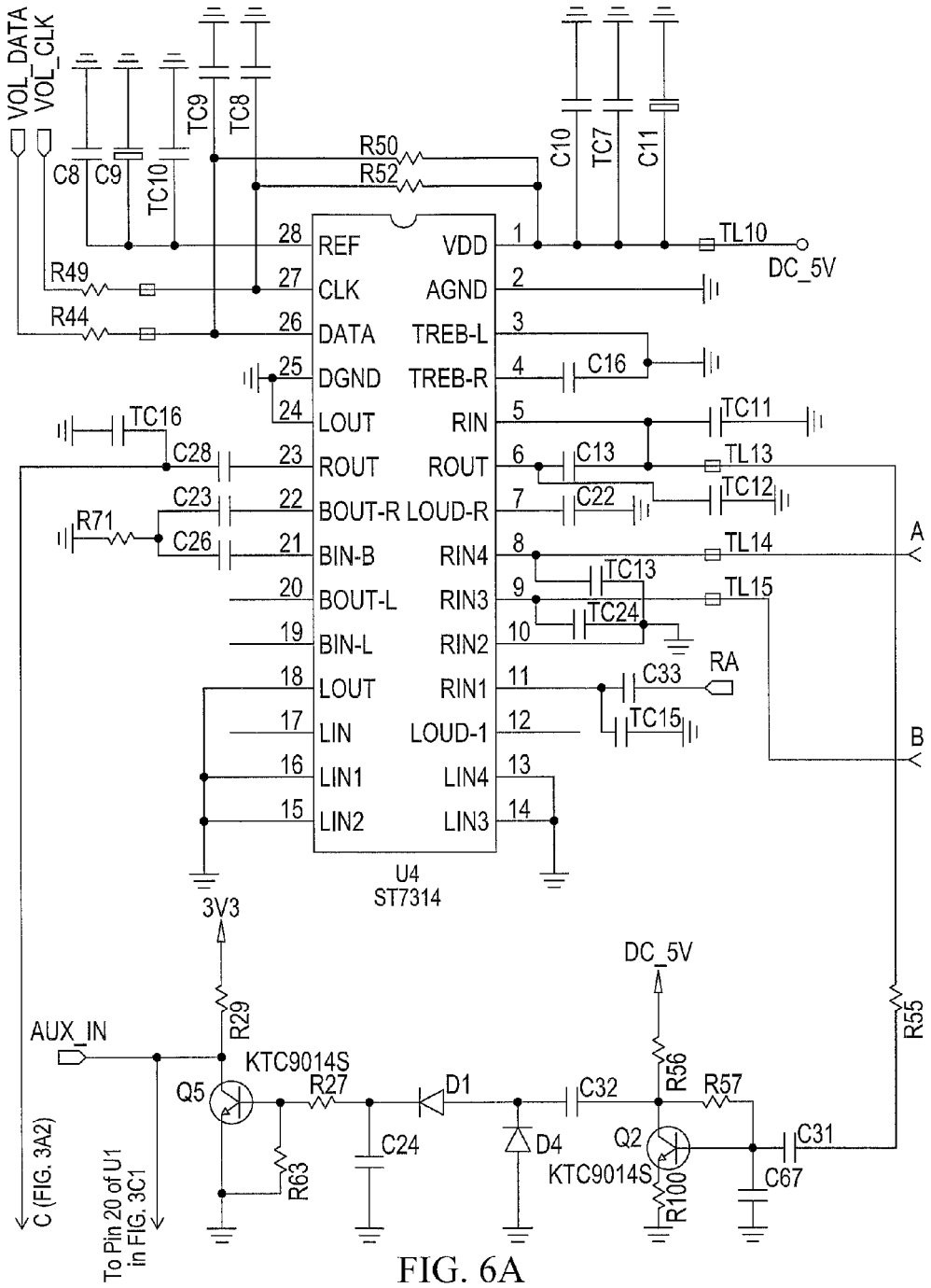

VOL_DATA
VOL_CLK
C8
C9
TC10
TC9
TC8
R50
R52
C10
TC7
C11
TL10
DC_5V
R49
R44
TC16
C28
C23
R71
C26
TC11
C13
TL13
TC12
C22
TL14
A
TC13
TL15
TC24
RA
C33
TC15
B
R55
28 REF
27 CLK
26 DATA
25 DGND
24 LOUT
23 ROUT
22 BOUT-R
21 BIN-B
20 BOUT-L
19 BIN-L
18 LOUT
17 LIN
16 LIN1
15 LIN2
VDD 1
AGND 2
TREB-L 3
TREB-R 4
RIN 5
ROUT 6
LOUD-R 7
RIN4 8
RIN3 9
RIN2 10
RIN1 11
LOUD-1 12
LIN4 13
LIN3 14
U4
ST7314
3V3
DC_5V
R29
AUX_IN
KTC9014S
Q5
R27
D1
C32
R56
R57
C24
D4
Q2
KTC9014S
C31
C67
R63
R100
C (FIG. 3A2)
To Pin 20 of U1 in FIG. 3C1

FIG. 6A

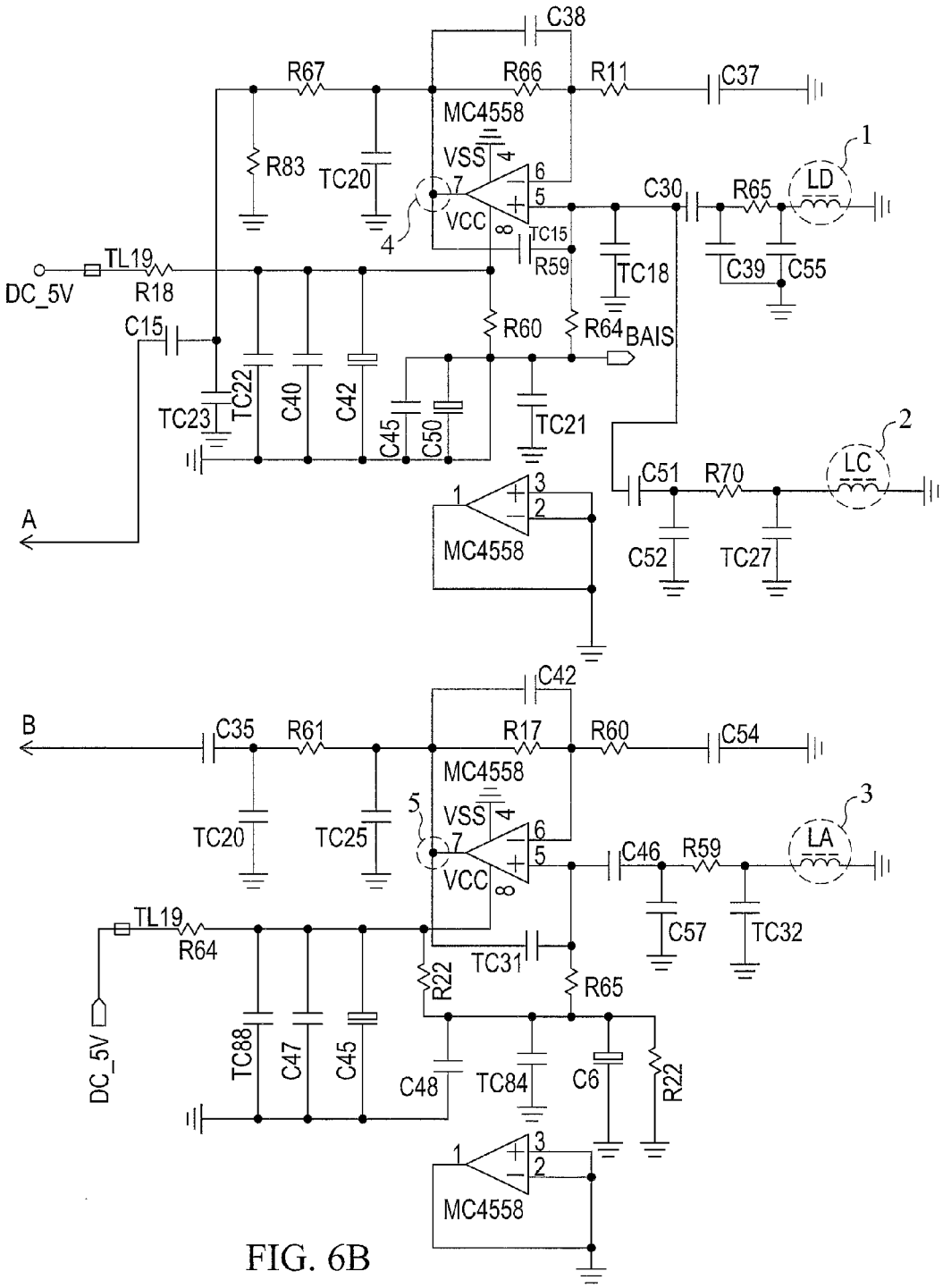

C38
R67
R66
R11
C37
MC4558
VSS
R83
TC20
VCC
C30
R65
LD
1
TL19
DC_5V
R18
TC15
R59
TC18
C39
C55
C15
R60
R64
BAIS
TC22
TC23
C40
C42
C45
C50
TC21
2
LC
C51
R70
A
MC4558
C52
TC27
C42
B
C35
R61
R17
R60
C54
MC4558
3
LA
TC20
TC25
VSS
C46
R59
VCC
TL19
R64
TC31
R22
R65
C57
TC32
DC_5V
TC88
C47
C45
C48
TC84
C6
R22
MC4558

FIG. 6B

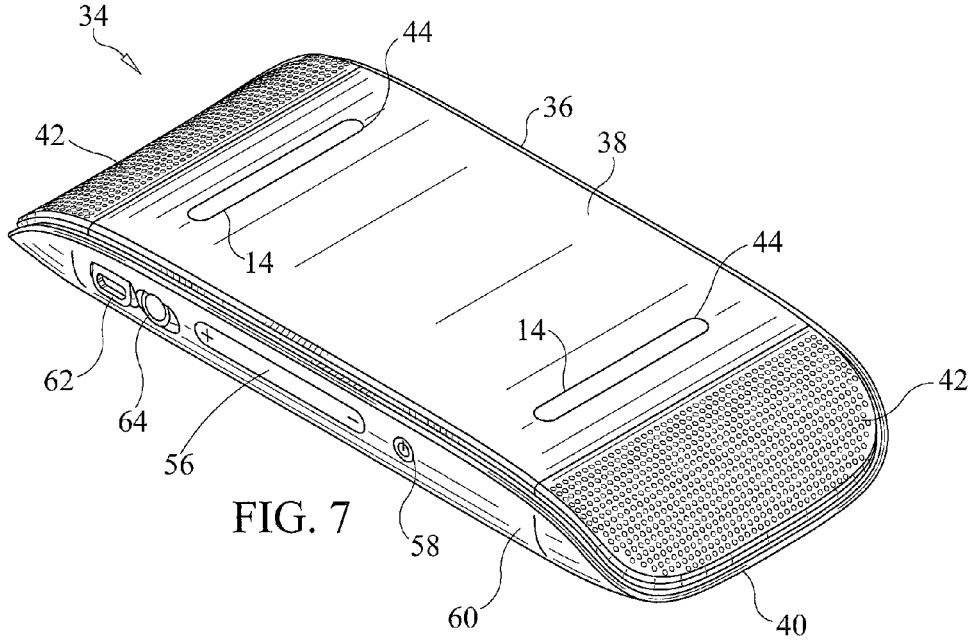


FIG. 7

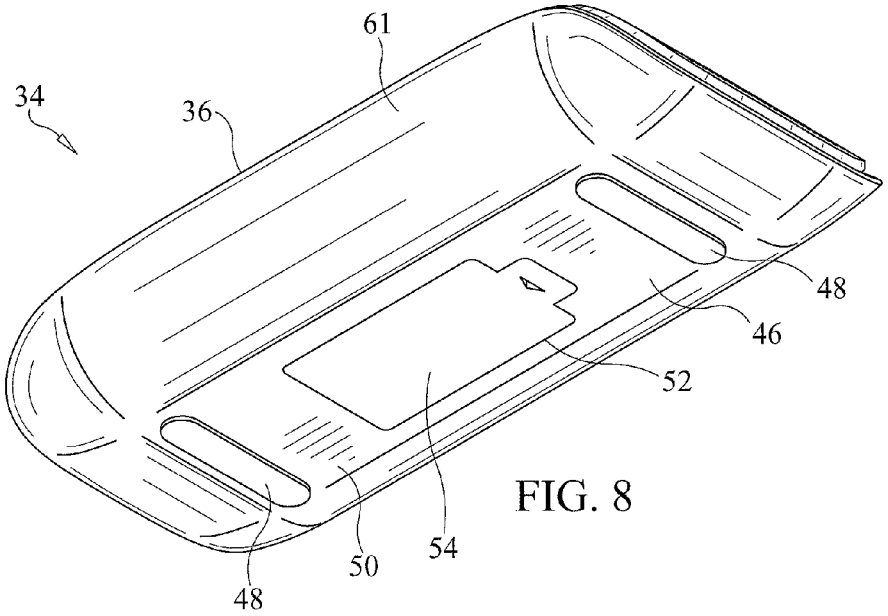


FIG. 8

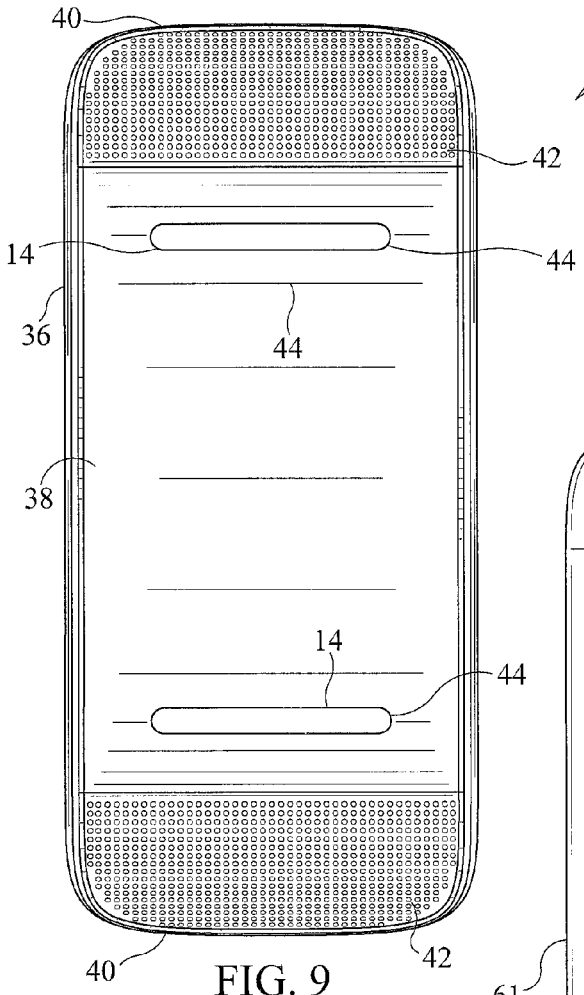


FIG. 9

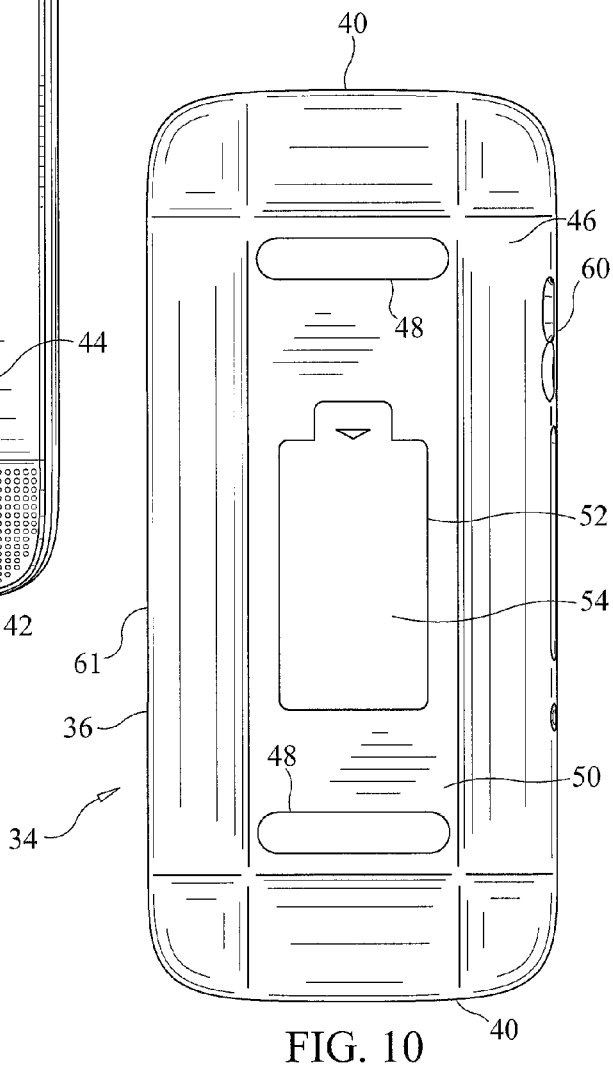


FIG. 10

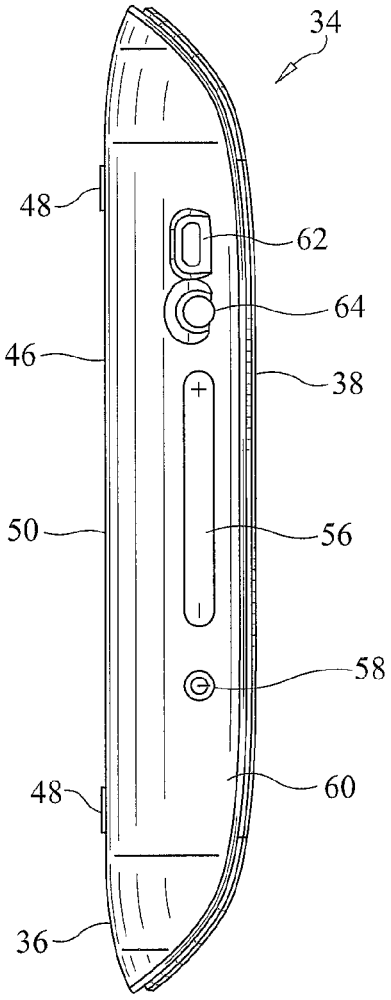


FIG. 11

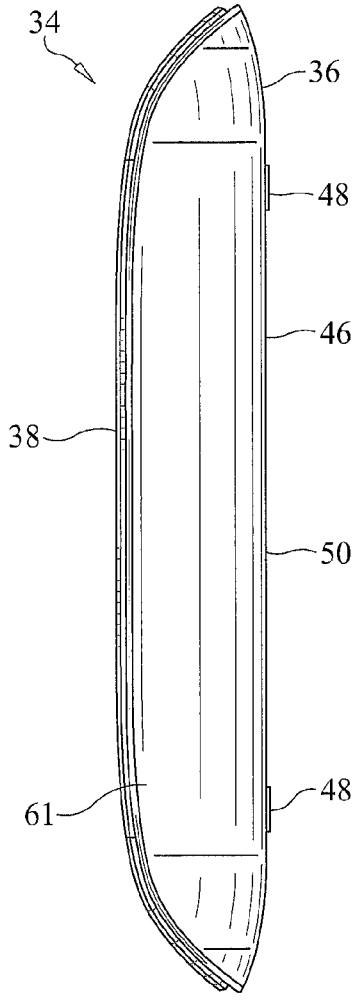


FIG. 12

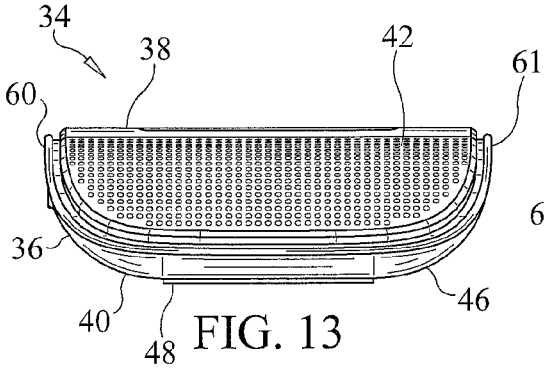


FIG. 13

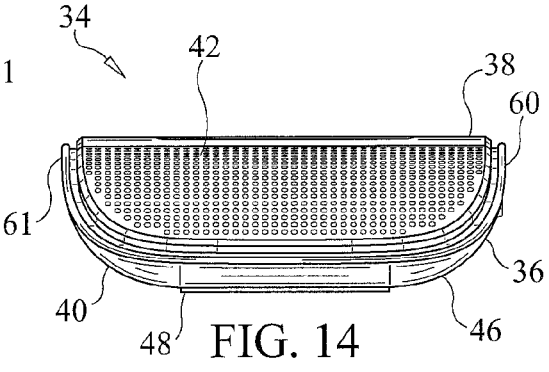


FIG. 14

WIRELESS AUDIO COUPLER AND AMPLIFIER FOR MOBILE PHONE, TABLET DEVICE, MP3 PLAYER AND THE LIKE

This application is related to U.S. Provisional Application Ser. No. 61/738,545, filed on Dec. 18, 2012, and entitled "Wireless Audio Coupler and Amplifier for Mobile Phone, Tablet Device, MP3 Player and the Like" and U.S. Provisional Application Ser. No. 61/836,472, filed on Jun. 18, 2013, and also entitled "Wireless Audio Coupler and Amplifier for Mobile Phone, Tablet Device, MP3 Player and the Like", and U.S. Design Patent Application Ser. No. 29/466,502, filed on Sep. 9, 2013, and entitled "Housing for an Electronic Device", the disclosure of each of which is incorporated herein by reference and on which priority is hereby claimed.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an electronic circuit and method, and an apparatus, for wirelessly coupling one electronic device to another electronic device so that audio signals may be transferred between the devices.

2. Description of the Prior Art

It is known from early modems, facsimile machines and the like that to transfer signals in the audio or audible frequency range between electronic devices, the speaker of one device, often forming part of a telephone handset, is placed in close proximity to the microphone of the other device, often including a cradle in which the handset of the first device is received. Sound emanating from the speaker of the first device is received by the microphone of the second device. The microphone of the second device converts the sound into electrical signals, usable by the circuitry of the second device for carrying out a particular function, for example, amplification or transmission, by the second device.

The conversion of electrical signals to sound in the speaker of the first device, and re-conversion into electrical signals of the received sound by the microphone of the second device, may lead to errors and inaccuracies in the received and re-converted signals in the second device. Furthermore, the microphone of the second device may also be receiving background or ambient noise, which further affects the quality and fidelity of the re-converted electrical signals in the second device.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of the present invention to provide a wireless audio coupler circuit which can transfer audio signals from one electronic device to another electronic device.

It is another object of the present invention to provide a wireless audio coupler for use with a first electronic device, such as a mobile phone, tablet device, MP3 player and the like, which wireless audio coupler is housed within a second electronic device and which can transfer audio signals from the first electronic device to the second electronic device.

It is still another object of the present invention to provide a wireless audio coupler circuit housed within an amplifier device which effects the transfer of audio signals from a portable, handheld device to the amplifier device without the need to convert the electrical signals to audio (i.e., audible sound) in the first device and re-convert the audio sound to electrical signals in the amplifier device.

It is a further object of the present invention to provide an amplifier device which may be wirelessly coupled to a portable handheld device to receive audio signals therefrom and amplify the audio signals.

It is yet a further object of the present invention to provide a wireless audio coupler circuit or device which overcomes the inherent disadvantages of conventional audio coupling devices.

In accordance with one form of the present invention, an audio coupler circuit for wirelessly coupling a portable, handheld electronic device, such as a mobile phone, tablet device, MP3 player and the like, to an amplifier circuit of a second electronic device, for example, a clock radio, preferably resides in the second device. The audio coupler circuit includes one or more magnetic signal pick-up coils placed at specific locations on or in close proximity to the housing of the second electronic device. An area on the exposed outer surface of the housing is marked to show to a user where he should place his handheld device thereon. The magnetic signal pick-up coil, or coils, are situated in locations where at least one of the pick-up coils would be in close proximity to where the built-in internal speaker of most if not all handheld devices currently on the market is located, when the handheld device is placed on the designated area of the exterior surface of the housing of the second electronic device (e.g., the clock radio). The pick-up coil that is closest to the internal speaker of the handheld device senses the strongest magnetic signal from the speaker coil in the handheld device and, through inductive coupling with the speaker coil, provides a corresponding output signal to the amplifier circuit of the second electronic device. In this way, the audio signal provided to the speaker of the handheld device, when the handheld device is placed on the housing of the second device, is amplified and the audio sound corresponding thereto is played through the speaker of the second electronic device.

These and other objects, features and advantages of the present invention will be apparent from the following detailed description of illustrative embodiments thereof, which is to be read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A and **1**B are perspective views of a digital clock radio embodying the wireless audio coupler circuit of the present invention, FIG. **1**A illustrating a raised portion of the housing of the digital clock radio on which a portable, handheld electronic device is to be placed, and FIG. **1**B showing a portable, handheld device placed on the raised portion of the housing of the digital clock radio, the digital clock radio and wireless audio coupler circuit situated therein being formed in accordance with the present invention.

FIG. **2** is a perspective view of an alternative form of the digital clock radio of the present invention, having a raised portion of the housing, and incorporating the wireless audio coupler circuit of the present invention.

FIG. **3** (i.e., FIGS. **3**A**1**, **3**A**2**, **3**B, **3**C**1** and **3**C**2**) is a schematic diagram of the clock radio of the present invention, showing the wireless audio coupler circuit of the present invention forming part thereof.

FIG. **4** is a block diagram of an alternative form of the wireless audio coupler circuit and an amplifier circuit formed in accordance with the present invention, which uses a tape head, such as found in a cassette tape player, for magnetically or inductively coupling the speaker of a portable, handheld electronic device to the amplifier circuit formed in accordance with the present invention.

FIG. **5** is another block diagram illustrating the coupling between the wireless audio coupler circuit of the present invention, using a tape head for magnetically or inductively coupling an amplifier circuit to the internal speaker of the handheld electronic device.

FIG. **6** (i.e., FIGS. **6**A and **6**B) is a schematic diagram of an alternative version of the wireless audio coupler circuit of the present invention used in the clock radio of the present invention.

FIG. **7** is a front, top perspective view of another form of an amplifier device including a wireless audio coupler circuit and formed in accordance with the present invention.

FIG. **8** is a rear, bottom perspective view of the amplifier device of the present invention shown in FIG. **7**.

FIG. **9** is a top plan view of the amplifier device of the present invention shown in FIGS. **7** and **8**.

FIG. **10** is a bottom plan view of the amplifier device of the present invention shown in FIGS. **7-9**.

FIG. **11** is an elevational view of a first lateral side of the amplifier device of the present invention shown in FIGS. **7-10**.

FIG. **12** is an elevational view of a second lateral side of the amplifier device of the present invention shown in FIGS. **7-11**.

FIG. **13** is an elevational view of a first speaker side of the amplifier device of the present invention shown in FIGS. **7-12**.

FIG. **14** is an elevational view of a second speaker side of the amplifier device of the present invention shown in FIGS. **7-13**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference should now be had initially to FIGS. **1**A, **1**B and **2** of the drawings. In each of these figures, a digital clock radio **2** formed in accordance with the present invention is shown. The digital clock radio **2** includes conventional circuitry, as is well known in the art, but also includes the wireless audio coupler circuit **3** of the present invention so that audio signals provided to a speaker **80** (see FIG. **5**) of a portable, handheld device **4** may be transferred through inductive coupling to the amplifier circuit within the digital clock radio **2**, which can provide amplified audio through the loudspeaker **5** of the clock radio **2** which corresponds to the audio signal provided to the speaker of the handheld device **4**.

As can be seen in FIGS. **1**A, **1**B and **2**, the digital clock radio **2** is modified so that its housing **6** has a designated area **8** for the user to place his portable, handheld device **4** thereon. Such a device **4** includes, but is not limited to, a mobile phone, a tablet device and an MP3 player.

The area **8** on the exterior surface on the housing **6**, designated for placement of the handheld electronic device **4** thereon, may be slightly raised above the rest of the exterior surface of the housing **6**, and may be sloped at an angle, to indicate to a user where to place and orient thereon the handheld device **4**. As shown in FIG. **1**B, the handheld device **4** is placed on a raised portion **10** of the top surface **12** of the housing **6** of the digital clock radio **2** such that the top of the device **4** is positioned over the higher portion of the raised area **10** of the housing surface **12**, and the bottom of the device **4** is positioned at the lower portion of the raised surface area **10**. The raised and sloping surface **10** of the housing **6** over this designated area **8** insures that the handheld electronic device **4** will be placed thereon in a particular orientation so that the internal speaker of the portable electronic device **4** will be in close proximity to one or more magnetic signal pick-up coils **11** (or tape heads **13**) of the wireless audio coupler circuit **3** forming part of the digital clock radio **2**. The portion **10** of the housing **6** over the designated area **8** is also preferably raised so that it is easier for the user to view any messages on the display of the handheld device **4** when it is resting on the housing **6**, for example, so that the user may see what song is being played through the speaker of the digital clock radio **2**.

Although the designated area **8** shown in FIGS. **1**A, **1**B and **2** is illustrated as a raised section **10** of the top surface **12** of the housing **6**, it is envisioned to be within the scope of the present invention to have an unraised area with markings thereon, such as a rectangular line **14** (see FIGS. **7** and **9**) surrounding the area **8**, or a recessed area of the housing **6**, to indicate to a user where to place his smart phone, cellular phone or other handheld device **4** on the housing **6** of the digital clock radio **2**.

There are many brands of smart phones and cellular phones currently on the market. These include the Apple iPhone™, the Samsung Galaxy™, the Blackberry™, the Droid™ phone manufactured by HTC Corporation and mobile phones manufactured by LG Electronics Inc. Each brand of cellular phone and smart phone may have the internal speaker situated in a different location on the housing of the phone (e.g., the top, middle or bottom portion of a smart phone or cellular phone). To insure that maximum coupling between the wireless audio coupler circuit **3** and the speaker coil of the smart phones and cellular phones of each of the major brands, and to insure that the digital clock radio **2** of the present invention, incorporating the wireless audio coupler circuit **3** of the present invention, will work with most major brands of cellular phones and smart phones, a plurality of magnetic signal pick-up coils **11** (or tape heads **13**) is used in the audio coupler circuit **3** of the present invention and placed in specific locations within or under the area **8** of the housing **6** of the digital clock radio **2** designated for the user to place his smart phone, cellular phone or other handheld device **4** thereon such that at least one of the magnetic signal pick-up coils **11** will be in close proximity to the internal speaker of the smart phone or cellular phone **4** placed on the designated area **8** of the housing **6** of the digital clock radio **2**.

Preferably, three magnetic signal pick-up coils **11** (or tape heads **13**) are used in the present invention, one being located directly adjacent to the housing **6**, or incorporated in the housing **6**, centrally in the top portion **16** of the designated area **8** thereof (near the highest raised portion of the housing **6**), and two magnetic signal pick-up coils **11** (or tape heads **13**) being situated near the left and right, opposite lateral sides directly adjacent to or incorporated within the lower portion **18** of the designated area **8** of the housing **6** (where the designated area is less raised above the rest of the housing **6** of the digital clock radio **2**). The preferred locations of the magnetic signal pick-up coils **11** are determined by the locations of the internal speakers of the smart phones, cellular phones and other portable, handheld devices **4** that are currently being marketed, so that at least one of the magnetic signal pick-up coils **11** will be in close proximity to the internal speaker coil of a cellular phone or smart phone placed in the designated area **8** of the housing **6** of the digital clock radio **2** of the present invention.

It has been found through experimentation that a magnetic signal pick-up coil **11** having an inductance in the range of about ten milliHenries (ten mH) to about three hundred, thirty milliHenries (330 mH) is suitable for use in detecting the magnetic radiation field from the coil of a speaker of a cellular phone or smart phone; however, it has been further found that the best value of inductance of the magnetic signal pick-up

coil **11** used in the wireless audio coupler circuit **3** of the present invention is equal or close to the inductance range from about forty milliHenries (40 mH) to about one hundred milliHenries (100 mH). With this inductance, the magnetic signal pick-up coil **11** provides the strongest current and voltage through its inductive coupling with the coil of the internal speaker of the cellular phone or smart phone. As will be explained in greater detail, a cassette head **13** from a conventional cassette tape player may be used as a magnetic signal pick-up device, one or more of the cassette heads **13** being positioned in or in close proximity to the housing **6** within the designated area **8** of the housing of the digital clock radio **2** and at specific locations within the area **8**, such as described previously.

The magnetic signal pick-up coil **11** (or tape head **13**) should be placed as close as possible to the anticipated location of the speaker of a cellular phone or smart phone placed on the housing **6** of the digital clock radio **2**, and it would be preferred if the magnetic signal pick-up coil **11** is within ten millimeters (10 mm) of the speaker coil of the smart phone or cellular phone. If necessary, the thickness of the housing **6** of the digital clock radio **2** over portions of the designated area **8** where the magnetic signal pick-up coils **11** are located may be thinned, with the pick-up coils **11** being situated directly beneath and adjacent to the thinned portions of the housing **6**. Alternatively, the magnetic signal pick-up coils **11** may be incorporated directly into the housing **6** of the digital clock radio **2** at specific locations within or in proximity to the designated area **8** to insure sufficient inductive coupling with any cellular phone, smart phone or other portable electronic device **4** placed thereon.

A schematic circuit diagram of a digital clock radio **2**, modified to include the wireless audio coupler circuit **3** of the present invention, is shown in FIG. **3** (i.e., FIGS. **3**A**1**, **3**A**2**, **3**B, **3**C**1** and **3**C**2**) of the drawings. A major portion of the circuit shown in FIG. **3** is used in a conventional digital clock radio. The modified portion thereof, incorporating the wireless audio coupler circuit **3** of the present invention, will now be described. Nevertheless, it should be realized that the wireless audio coupler circuit **3** of the present invention may be incorporated in other electronic devices, such as cassette tape players, stereo or monoral receivers, and amplifier devices, and is not limited in use to just a clock radio.

Preferably, there are three magnetic signal pick-up coils **11** forming part of the wireless audio coupler circuit **3** of the present invention and incorporated into the electronic circuit of the digital clock radio **2** of the present invention. The three magnetic signal pick-up coils **11** are labeled in FIG. **3** as LA, LC and LD. Each magnetic signal pick-up coil LA, LC, LD is situated in a particular location within the designated area or areas **8** of the housing **6** of the digital clock radio **2** so that at least one of the magnetic signal pick-up coils **11** will be in close proximity to the internal speaker of a cellular phone or smart phone **4** placed on the designated area **8** of the housing **6** of the digital clock radio **2**.

One end of each of the magnetic signal pick-up coils LA, LC, LD is grounded, while the other end is provided to a pre-amplifier circuit through a DC blocking capacitor C**46**, C**237** and C**357**, respectively. Each pre-amplifier circuit is preferably formed using an operational amplifier IC**2**-B, IC**404**-A and IC**404**-B, such as found in dual general purpose operational amplifier integrated circuit RC4558 manufactured by Texas Instruments, or its equivalent. Each operational amplifier IC**2**-B, IC**404**-A and IC**404**-B is configured as an inverting amplifier, including feedback resistors R**17**, R**218** and R**318** and input resistors R**59**, **8219** and R**320**, respectively. Pre-amplifier circuits are preferably used, since the output signals from the magnetic signal pick-up coils **11** are rather weak, that is, at a very low voltage level.

The amplified output signals of the three pre-amplifier circuits are respectively provided to the RIN**2**, RIN**3** and RIN**4** inputs of a four channel digital audio processor IC**402**, preferably having Part No. PT2314, manufactured by Princeton Technology Corp. The audio processor IC**402** acts as a "greatest of" circuit by determining which signal sensed by each magnetic signal pick-up coil LA, LC, LD is the greatest voltage, amplified by the pre-amplifier circuits. The greatest magnitude signal is provided on the right speaker signal output port PIN **23** of the PT2314 circuit IC**402**, which output signal is provided through the conventional power amplifier circuits of the digital clock radio to the speaker **5** thereof. For more information on the connections and operations of the four channel digital audio processer PT2314 circuit IC**402**, reference should be had to the data and application sheets and specifications published by Princeton Technology Corp., such as document no. PT2314v1.1, dated March, 1999, and which may be found at http://www.princeton.com.tw, the disclosure of which is incorporated herein by reference.

An alternative version of the wireless audio coupler circuit **3** of the present invention used in a clock radio is shown in FIG. **6** (i.e., FIGS. **6**A and **6**B) of the drawings. Here, a first pre-amplifier circuit formed of an operational amplifier U**7**-**5**, preferably forming part of a dual wide bandwidth bipolar operational amplifier integrated circuit, such as having Part No. MC4558 manufactured by STMicroelectronics, or an equivalent thereof by another manufacturer, configured as a non-inverting amplifier, receives on its non-inverting input the corresponding output signal of one of the magnetic signal pick-up coils LA (see Circle **3** in FIG. **6**), which preferably has an inductance of forty milliHenries (40 mH). The output of the first pre-amplifier circuit is noted at Circle **5** in FIG. **6**, and the output signal thereat is provided to the RIN**3** input of the four channel digital audio processor U**4**, preferably having Part No. PT2314, manufactured by Princeton Technology Corp., as before with the circuit shown in FIG. **3**, or its equivalent, such as Part No. ST2314 manufactured by STMicroelectronics.

A second pre-amplifier circuit, being formed of an operational amplifier U**6**-**5**, also preferably forming part of a dual operational amplifier integrated circuit having Part No. MC4558, also configured as a non-inverting amplifier, receives on its non-inverting input the summed corresponding output signals of the two other magnetic signal pick-up coils LC and LD (see Circles **2** and **1**, respectively, in FIG. **6**), each of which also preferably has an inductance of forty milliHenries (40 mH). The output of the second pre-amplifier circuit is noted at Circle **4** in FIG. **6**, and the output signal thereat is provided to the RIN**4** input of the audio processor circuit U**4**. As with the wireless audio coupler circuit of FIG. **3**, the audio processor U**4** will select the strongest amplified signal from either the first pick-up coil LA, or from the combination of the second and third pick-up coils LC and LD, to be amplified by the power amplifier circuitry of the clock radio **2**, as described previously in relation to the circuit shown in FIG. **3**.

As mentioned previously, a tape head **13** of a conventional cassette tape player may be used instead of a magnetic signal pick-up coil **11**. A wireless audio coupler circuit **3**, using such a tape head **13**, is illustrated by FIGS. **4** and **5** of the drawings.

As shown in FIG. **4**, the magnetic field radiating from the coil of the internal speaker of a cellular phone, smart phone or other portable, handheld electronic device **4** is picked up (i.e., sensed) by the playback tape head **13** found in a conventional cassette tape player. The output signal from the tape head **13**

is provided to an amplifier, such as the playback pre-amplifier **20** found in a conventional cassette tape player, and the output signal of the playback pre-amplifier **20** is provided to the power amplifier **22** of a conventional tape cassette player, whose amplified output signal, in turn, is provided to the loudspeaker **5** of a conventional cassette tape player.

An electronic device having the features of a cassette tape player **23** is shown in FIG. **5** of the drawings. The tape head **13** is placed within close proximity to the internal speaker **80** of the cellular phone, tablet device, MP3 player or other electronic handheld device **4** and preferably within a distance therefrom of about ten (10) millimeters or less so that the tape head **13** will be magnetically coupled to the internal speaker **80** of the handheld device **4**. The output signal of the tape head **13** is provided to a pre-amplifier circuit **24** having high gain, and preferably the output signal of the pre-amplifier circuit **24** is provided to an equalizer circuit **26**. The equalizer circuit **26** is preferably included to provide an optimum frequency response. As is well known, a plurality of switches and/or potentiometers **28** may be connected to the equalizer circuit **26** so that the user may adjust the frequency response over the audio band. The output signal of the equalizer circuit **26** is provided to a power amplifier **30**, where volume may be controlled by the user using a potentiometer **32**, and the output signal of the power amplifier **30** is provided to a loudspeaker **5**.

The circuitry just described, that is, the pre-amplifier circuit **24**, equalizer circuit **26** and power amplifier circuit **30**, may form part of a conventional cassette tape player **23** that has an area **8** of its housing designated for placement of a cellular phone, smart phone or other portable, handheld device **4**, in a manner similar to that described previously with respect to the digital clock radio **2**, and the audio signal from the cellular phone or smart phone may be picked up (sensed) by the tape head **13** of the cassette tape player **23**, where the tape head **13**, or a plurality of tape heads **13**, is positioned close to the housing and within the designated area **8** of the housing so that the tape head **13** magnetically couples to the internal speaker **80** of the cellular phone or smart phone placed against the designated area **8** of the housing. Alternatively, it may be that the existing tape head **13** used in the conventional cassette tape player **23** for sensing the magnetic signals on the cassette tapes may be situated sufficiently close to the housing of the player where the handheld device **4** is placed so as to magnetically couple to the internal speaker **80** of the handheld device placed against the housing, and no additional tape heads **13** or magnetic signal pick-up coils **11** need to be incorporated in the cassette tape player **23** modified to incorporate the wireless audio coupler circuit **3** of the present invention.

In an alternative version of the present invention, rather than incorporating the wireless audio coupler circuit **3** in an existing electronic device, such as a digital clock radio **2** or cassette tape player **23** as described previously, a separate amplifier device **34** having the wireless audio coupler circuit **3** incorporated therein may be constructed. The separate amplifier device **34** would include a housing **36** having a designated area **8** on which the user may place his cellular phone, smart phone or other portable, handheld device **4**, as described previously. One or more magnetic signal pick-up coils **11** (or tape heads **13**) would be disposed at selected locations within the designated area **8** of the housing **36** of the amplifier device **34** to be in close proximity to the internal speaker of the handheld device **4**, as also described previously. The amplifier device **34** may include a pre-amplifier circuit **24**, an equalizer circuit **26**, a power amplifier circuit **30** and one or more loudspeakers **5**, as described previously and shown in FIG. **5** of the drawings, so that the audio signals of the speaker coil within the handheld device **4** are inductively or magnetically coupled to the magnetic signal pick-up coils **11** or tape heads **13** of the amplifier device **34**, with the output signals from the coils **11** or tape heads **13** being pre-amplified, equalized in frequency response, power amplified and provided to a loudspeaker **5** forming part of the amplifier device **34** so that the user may hear an amplified version of the audio from the internal speaker of his cellular phone, smart phone or other handheld device **4**. Such a separate amplifier device **34** is shown by way of example in FIGS. **7-14** of the drawings.

As can be seen from FIGS. **7-14**, the amplifier device **34** has a generally planar housing **36** which defines an interior cavity for housing the electronic circuitry described previously, which may include a pre-amplifier circuit **24**, an equalizer circuit **26**, a power amplifier circuit **30** and one or more loudspeakers **5**, as well as the wireless audio coupler circuit **3** also described previously. The top surface **38** of the housing **36** preferably slopes at opposite narrower sides **40**, where speaker grills **42** are incorporated into the top surface **38**, the grills **42** covering loudspeakers **5** placed beneath them and connected to the internally disposed power amplifier circuit **30**. In an alternative embodiment, the amplifier device **34** may include one or more loudspeakers **5** and one or more passive radiators (i.e., a "drone cone", without a magnet and voice coil) **82** situated beneath one or more of the grills **42**. If the loudspeaker **5** and passive radiator **82** are remotely located on the housing **36** beneath individual loudspeaker grills **42**, they may be acoustically coupled together through the interior cavity defining an internal sound chamber within the amplifier device **34**. Markings or other indicia **44**, preferably colored lines that define two oblong or rectangular shapes **14** which extend laterally across the top surface **38** of the housing **36**, in proximity to the opposite narrower side portions **40** of the housing **36**, are provided for the user to know where the magnetic signal pick-up coils **11** are located beneath the top surface **38** of the housing **36** and so that the user may place his smart phone or other electronic device **4** thereon such that the speaker of the smart phone or other electronic device **4** will be in close proximity to one of the magnetic signal pick-up coils **11** located in the amplifier device **34**, as indicated by the oblong or rectangular shaped lines **14**. This will ensure the best coupling between the speaker of the smart phone or other electronic device **4** and the magnetic signal pick-up coil or coils **11** (or tape heads **13**, if such are used) of the amplifier device **34** of the present invention.

The rear side **46** of the amplifier device **34**, as shown in FIGS. **8** and **10**, includes one or more non-slip rubber feet **48** mounted on the bottom surface **50** thereof, as well as a battery cabinet **52** for housing a battery for powering the amplifier device **34** of the present invention, the battery cabinet **52** being closable with a removable or pivotable door **54** that lies flush with the bottom surface **50** of the amplifier device housing **36**.

As can be seen from FIG. **11** of the drawings, the amplifier device **34** of the present invention preferably includes a volume control in the form of a rocker switch **56** for controlling the volume of the sound emitted by the amplifier device **34**, as well as a power, push button switch **58** for controlling the energization of the amplifier device **34** of the present invention, each of the switches **56**, **58** being mounted on one lateral side **60** of the amplifier device.

On the same or opposite lateral side **61** of the amplifier device **34** of the present invention, and as shown in FIG. **11** of the drawings, preferably the amplifier device **34** includes a micro USB connector **62** for charging the battery of the amplifier device **34** or for powering the amplifier device by an

external power source, and an auxiliary jack or other connector **64** for connecting the amplifier device **34** of the present invention to a peripheral speaker or other amplifier circuit or device.

As can be seen from the foregoing description, and as shown in the drawings, the device of the present invention, whether it is in the form of a clock radio **2**, cassette tape player **23** or a separate amplifier device **34**, having incorporated therein the wireless audio coupler circuit **3**, allows a user of a handheld electronic device **4** to easily amplify the sounds emanating from the handheld device through the loudspeaker **5** of the amplifier device wirelessly by simply resting the handheld device **4** on the designated area **8** of the housing of the amplifier device. No wired connection is required, as the speaker coil in the handheld device **4** will be inductively or magnetically coupled to the amplifier device through the strategically placed magnetic pick-up coils **11**, **13** of the amplifier device. The handheld device **4** and amplifier device are easily decoupled by removing the handheld device from the designated resting area **8** of the housing of the amplifier device.

Although illustrative embodiments of the present invention have been described herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various other changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the invention.

What is claimed is:

1. An electronic amplifier device, which comprises:

a housing, the housing defining an interior space;

an area on the housing designated for placement of a portable electronic device thereon;

an amplifier circuit situated within the interior space defined by the housing;

at least one loudspeaker electrically coupled to the amplifier circuit and situated in proximity to the housing; and

a wireless audio coupler circuit situated within the interior space defined by the housing and electrically coupled to the amplifier circuit, the wireless audio coupler circuit including at least one magnetic signal sensing device, the at least one magnetic signal sensing device being situated in close proximity to the designated area on the housing for sensing magnetic signals emanating from the portable electronic device placed on the designated area of the housing.

2. An electronic amplifier device as defined by claim **1**, wherein the at least one magnetic signal sensing device includes a magnetic signal pick-up coil.

3. An electronic amplifier device as defined by claim **1**, wherein the at least one magnetic signal sensing device includes a playback tape head.

4. An electronic amplifier device as defined by claim **1**, wherein the housing includes a raised portion and an unraised portion adjacent to the raised portion, the raised portion of the housing being situated in alignment with the designated area on the housing, the raised portion of the housing being provided for placement of the portable electronic device thereon.

5. An electronic amplifier device as defined by claim **4**, wherein the raised portion of the housing is sloped relative to the unraised portion of the housing.

6. An electronic amplifier device as defined by claim **1**, wherein the housing includes indicia situated thereon to indicate the area on the housing designated for placement of the portable electronic device thereon.

7. An electronic amplifier device as defined by claim **1**, wherein the at least one magnetic signal sensing device includes at least a first magnetic signal sensing device and a second magnetic signal sensing device, each of the at least first magnetic signal sensing device and the second magnetic signal sensing device being spaced apart from one another and being situated in close proximity to the area on the housing designated for placement of the portable electronic device thereon, each of the at least first magnetic signal sensing device and the second magnetic signal sensing device generating sensed output signals in response to magnetic signals sensed by the at least first magnetic signal sensing device and the second magnetic signal sensing device;

wherein the wireless audio coupler circuit further includes at least a first pre-amplifier circuit and a second pre-amplifier circuit, the first pre-amplifier circuit being electrically coupled to the first magnetic signal sensing device, and the second pre-amplifier circuit being electrically coupled to the second magnetic signal sensing device, the at least first pre-amplifier circuit and the second pre-amplifier circuit respectively generating a first pre-amplified output signal and a second pre-amplified output signal respectively in response to the sensed output signals generated by the at least first magnetic signal sensing device and the second magnetic signal sensing device;

and wherein the wireless audio coupler circuit further includes a processing circuit which determines which of the at least first pre-amplified output signal and the second pre-amplified output signal has the greatest magnitude.

8. An electronic amplifier device as defined by claim **1**, wherein the housing is in the form of a generally elongated, planar structure having a first narrow side and a second narrow side situated opposite the first narrow side;

wherein the electronic amplifier device further comprises a first loudspeaker grill mounted on the housing and situated in proximity to the first narrow side thereof, and a second loudspeaker grill mounted on the housing and situated in proximity to the second narrow side thereof; and

wherein the at least one loudspeaker includes a first loudspeaker and a second loudspeaker, the first loudspeaker being situated in proximity to the first loudspeaker grill, and the second loudspeaker being situated in proximity to the second loudspeaker grill.

9. An electronic amplifier device as defined by claim **1**, which further comprises:

at least one loudspeaker grill mounted on the housing, and at least one passive radiator situated in proximity to the at least one loudspeaker so as to be acoustically coupled thereto, at least one of the at least one loudspeaker and the at least one passive radiator being situated in proximity to the at least one loudspeaker grill.

10. An electronic amplifier device as defined by claim **1**, which further comprises a digital clock radio circuit.

11. An electronic amplifier device as defined by claim **1**, which further comprises a tape cassette player circuit.

12. A method for wirelessly transferring audio signals from a portable electronic device to an electronic amplifier device without the need to convert the audio signals to audio sound in the portable electronic device and re-convert the audio sound to electrical signals in the electronic amplifier device, the electronic amplifier device having a housing, the housing defining an interior space, an area on the housing designated for placement of the portable electronic device thereon, an amplifier circuit situated within the interior space defined by the housing, at least one loudspeaker electrically coupled to the amplifier circuit and situated in proximity to the housing,

and a wireless audio coupler circuit situated within the interior space defined by the housing and electrically coupled to the amplifier circuit, the wireless audio coupler circuit including at least one magnetic signal sensing device, the at least one magnetic signal sensing device being situated in close proximity to the designated area on the housing for sensing magnetic audio signals emanating from the portable electronic device placed on the designated area of the housing, which comprises the steps of:

placing the portable electronic device on the area on the housing of the electronic amplifier device designated for placement of the portable electronic device thereon;

sensing by the at least one magnetic signal sensing device of the electronic amplifier device magnetic audio signals generated by the portable electronic device and generating a sensed output signal in response thereto;

amplifying by the amplifier circuit of the electronic amplifier device the sensed output signal and generating an amplified output signal in response thereto; and

providing the amplified output signal to the at least one loudspeaker of the electronic amplifier device.

13. A method for wirelessly transferring audio signals from a portable electronic device to an electronic amplifier device without the need to convert the audio signals to audio sound in the portable electronic device and re-convert the audio sound to electrical signals in the electronic amplifier device, the electronic amplifier device including a housing, the housing defining an interior space, an area on the housing designated for placement of the portable electronic device thereon, an amplifier circuit situated within the interior space defined by the housing, at least one loudspeaker electrically coupled to the amplifier circuit and situated in proximity to the housing, and a wireless audio coupler circuit situated within the interior space defined by the housing and electrically coupled to the amplifier circuit, the wireless audio coupler circuit including at least a first magnetic signal sensing device and a second magnetic signal sensing device, each of the at least first magnetic signal sensing device and the second magnetic signal sensing device being spaced apart from one another and being situated in close proximity to the area on the housing designated for placement of the portable electronic device thereon, the at least first magnetic signal sensing device and the second magnetic signal sensing device respectively generating at least a first sensed output signal and a second sensed output signal in response to magnetic audio signals respectively sensed by the at least first magnetic signal sensing device and the second magnetic signal sensing device, at least a first pre-amplifier circuit and a second pre-amplifier circuit, the first pre-amplifier circuit being electrically coupled to the first magnetic signal sensing device, and the second pre-amplifier circuit being electrically coupled to the second magnetic signal sensing device, the at least first pre-amplifier circuit and the second pre-amplifier circuit respectively generating at least a first pre-amplified output signal and a second pre-amplified output signal respectively in response to the at least first sensed output signal and the second sensed output signal generated by the at least first magnetic signal sensing device and the second magnetic signal sensing device, and a processing circuit which determines which of the at least first pre-amplified output signal and the second pre-amplified output signal has the greatest magnitude, which comprises the steps of:

placing the portable electronic device on the area on the housing of the electronic amplifier device designated for placement of the portable electronic device thereon;

sensing by the at least first magnetic signal sensing device and the second magnetic signal sensing device of the electronic amplifier device magnetic audio signals generated by the portable electronic device and respectively generating the at least first sensed output signal and the second sensed output signal in response thereto;

pre-amplifying by the at least first pre-amplifier circuit and the second pre-amplifier circuit of the electronic amplifier device the at least first sensed output signal and the second sensed output signal and respectively generating the at least first pre-amplified output signal and the second pre-amplified output signal in response thereto;

determining by the processing circuit of the electronic amplifier device which of the at least first pre-amplified output signal and the second pre-amplified output signal has the greatest magnitude;

amplifying by the amplifier circuit of the electronic amplifier device one of the at least first pre-amplified output signal and the second pre-amplified output signal which has the greatest magnitude and generating an amplified output signal in response thereto; and

providing the amplified output signal to the at least one loudspeaker of the electronic amplifier device.

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